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Report of the Astronomer Royal to the Board of Visitors of the Royal Observatory, Greenwich, read at the Annual Visitation of the Royal Observatory, 1857, *June* 6.

The following are a few extracts from this Report:—

"The foundations of the new South-eastern Dome have been laid, and I trust that the building will be completed in this summer. It is in the place which I indicated in the last Report, at the south-eastern corner of the Record Room, but not in contact with the Record Room. For explanation of the design generally, I beg leave to refer to the model which the Visitors have seen. I may here state that the local position of the building compelled me to make the entrances into the three separate stories through the middle of the North Pier. A large stove is provided for the lower story, the draft of which passes underground into the chimney of the Record Room; and I expect that this stove, by means of a trap in the first floor, will sufficiently warm and dry the second story. The dome will be drum-shaped, 29 feet in diameter inside, framed with vertical wooden standards upon horizontal curbs, and tied by diagonal iron hooping. It is to revolve on cannon-balls, and to be moved by toothed-wheel machinery carried by the dome, which acts upon a fixed rack of the wall-curb. The observing aperture will be 3 feet wide. The shutters will be two; a vertical wall-shutter, and a nearly horizontal roof-shutter, opening (for convenience of the mechanism) on opposite sides, each shutter opening independently of the other. Each shutter will carry a curved rack, to receive the action of a pinion carried by the solid parts of the dome. For the vertical shutter, I have made this rack jointed, and thereby I have been able to make the shutter flap close to the opening when it is closed, and flap close back to the dome-wall when it is opened, a condition which is not unimportant for preventing the wind from exerting any action to turn the dome. For the nearly horizontal shutter, I considered that the attempt to secure a shutter-movement of 180 degrees would introduce the necessity for the jointed rack, and would also require a complicated construction of counterpoises; and I have therefore avoided these by causing the shutter, both in its closed and in its opened state, to take a position inclined to the horizon, its angular movement being about 140 degrees; thus it will scarcely feel the wind, and the inclination will not be visible to spectators below. Other points can be explained orally. * * *

"The arrangement of the Board of Longitude papers has at last been taken up seriously, under the immediate superintendence of Mr. Main. * * * *

"In regard to the Reflex-Zenith Tube, I described in my last Report to the Visitors the construction which I proposed for destroying the tremors of the quicksilver by suspending its trough by means of straps of vulcanized caoutchouc, so as to leave it the

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utmost possible freedom of motion. The construction has been perfectly successful; the tremors are absolutely destroyed, and the star has been observed at all hours of night and day. It so happened that it was observed on the very day on which it passed with the sun. In the night-observations it is found that there is a perfectly steady nucleus, occasionally with rays twirling about it; the latter evidently arise from the deranged state of atmosphere, which seems usually incidental to a zenith-sector-room; to this I shall endeavour to give attention.

"The Altazimuth is in good order. A four-glass reflecting eyepiece has been made, which will tend to the facility and accuracy of observations at great elevations. I alluded in a preceding section to the cutting away of a very small portion of one of the rays of the three-armed pier which carries the Altazimuth. The quality of the brickwork is the best that I have ever seen, and not a single brick was disturbed beyond those actually removed. Yet the effect was to give the Altazimuth an inclination of about 23″. This inclination evidently depends on the elasticity of the brickwork. The angle between the axis of the vertical circle and the axis of general revolution, which at first was pretty exactly 90° 0′ 0″, has now become, by gradual change, about 90° 0′ 14″. The magnitude of the corresponding numerical correction to every observation of azimuth induces me to contemplate a re-adjustment of some of the mechanical connexions of the instrument.

"The Barrel Apparatus for chronographic record of transits has been in constant good order. To check the occasional tendency of the pendulum to describe an unreasonably large circle (from trifling inequalities in the maintaining power, which it is difficult to suppress entirely), I have mounted a slender spring, so as to produce, when the circle is large, a light friction. As every such friction is accompanied with force directed to the centre, it deranges the time of rotation. I have, however, planned a water-resistance which would be free from this objection, and which I may perhaps adopt in this instrument. A draftsman is at present employed in making plans of the barrel apparatus.

"The Galvanic Apparatus for clock movements is in the same state as last year, five clocks being in sympathetic movement in the Observatory, one at the Hospital Schools, and one in the North Kent Station at London Bridge. That for signals has received this slight alteration, that the pull of the Time Ball Detent now alters the connexions of four triplets of springs. Of these, one controls the communications with the Electric Telegraph Company's office at Lothbury; by which hourly signals are sent on various railways; the time-balls at the Strand, Cornhill, and Liverpool, are dropped; and the Post-office clock in Lombard Street is regulated. A second affects the communications with the South-Eastern Railway Station; by which hourly signals are sent on various lines in Kent, and the time-ball at Deal is dropped, and returns its signal to acquaint us with its successful drop. The third and fourth are reserved for the prospective wants of the

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Royal Dockyards; they communicate with the Admiralty wire of the British Telegraph. The communication with the Post-office clock is remarkable. At 23^{h} 26^{m} 0^{s} of that clock a signal is given to Greenwich, the comparison of which with our clock acquaints us with the error of the Post-office clock. At 0^{h} 0^{m} 0^{s} of the Greenwich clock a signal is sent from Greenwich which mechanically adjusts the Post-office clock. At 0^{h} 26^{m} 0^{s} of the Post-office clock a second signal is given to Greenwich, by which the efficiency of the adjustment is shown. I am in daily expectation of the extension of this system to three other clocks. * * *

"For the new S.E. equatoreal, the support of the north or upper end of the polar axis has been received, and is planted within the walls of the building in a position convenient for raising it to its ultimate destination. It is one piece of cast-iron, extending from about 18 inches below the floor of the room to the polar point; it weighs nearly 5 tons, and is considered to be a good specimen of Messrs. Ransomes' excellent castings. The base of the north support will be tied to the south support by horizontal iron rods under the floor. The two end-frames of the polar axis are prepared; a portion of one side of the upper end-frame is cut away, to permit uninterrupted vision as far as the pole. For moving the polar frame in right ascension, there will be an hour-circle moved by clock-work, similar to that of the Northumberland telescope, to which the polar frame may be clamped at pleasure. This hour-circle is to have a graduation at its edge to be viewed by a fixed microscope, and a graduation on its plane to be viewed by microscopes of the polar axis. The clock-work is to be driven by water power, derived from the supply-pipes, and acting by a reaction machine, as at Liverpool. I expect that, with a compensation-pendulum, with Sieman's chronometric governor, and with a proper water-resistance, as I have suggested above, I can give extreme accuracy to the motion in right ascension. For fixing the polar frame in hour-angle when transits, &c., are required, I propose a clamp independent of the hour-circle. The polar frame is to be entirely of iron, essentially on the principle of the Northumberland frame, but differing in several details, which will be best seen in the model. The declination-axis will be excentric, as explained by me last year. The clamping circle will be most conveniently carried by the polar axis, but the declination circle will be carried by the telescope, and will be viewed by two or more inclined microscopes, whose eye-ends are very close together, and very close to the pivot of the declination-axis. I anticipate that in this way the use of the declination-microscopes, ordinarily so troublesome, will be made comparatively easy. The illumination, I believe, can be conveniently thrown down the tubes of the microscopes themselves. The upper pivot of the polar axis and one pivot of the declination-axis are to be perforated for gas-pipes, and thus gaslight will be carried to every part of the frame where it may be required, even to the eye-end of the telescope.

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Those persons only who have used both oil lamps and gaslights under similar circumstances can fully appreciate the enormous advantage of this arrangement. Rings for galvanic contact will be mounted on the pivot of the polar axis, and on one pivot of the declination-axis, and thus the chronographic system, and possibly the sympathetic-clock system, will be carried to the eye-end of the telescope. The telescope tube will probably be of wood. This account, with inspection of the model, will perhaps give the Visitors a clear idea of my proposals regarding the equatoreal mounting. All this work is advancing in some degree, but there is still one important drawback; I have not yet received the object-glass. Messrs. Merz have not made a new object-glass to their satisfaction; they retain, however, the first in readiness, and can at any time transfer it for temporary use, so that I consider myself justified in making every possible preparation of mounting.

" *Astronomical Observations.* — The meridional system is sacredly preserved. Each star of a large clock-star-catalogue is observed, if possible, twenty times in three years; some stars are observed for refraction; some as having been compared with the moon; some on suspicion of proper motion, &c. The moon is observed at every opportunity, without exception. The sun and planets are observed at every opportunity, except on Sundays, and except when they pass later than 15^h in the morning, in which state the large planets only are observed, and only when the moon also is to be observed. The transits have been observed almost entirely by the chronographic method, except for the close circumpolar stars.

" The whole number of meridional observations from 1856, May 19, to 1857, May 23, is as follows:—In the department of transits: Observations of transits (reckoning two limbs, or two methods of observation by ear and by touch, as two observations), 4169; observations of collimator, by the telescope of the transit-circle, 311 pairs; observations of transit-wires by reflexion, 310; observations of one collimator by the other, 52. In the department of zenith-distances (reckoning two limbs, or a combination of direct observation with reflexion observation, as two observations, and including the observations of the wire by reflexion), circle observations of all kinds, 3663. * * *

" With the altazimuth, the moon has been completely observed on 198 days. This gives 15·8 per lunation. With the transit-circle the number of complete observations is 98, giving 7·8 per lunation. Of the observations with the altazimuth, 0 are on days when the moon passed between 0^h and 1^h of solar time, 3 when between 1^h and 2^h, 7 when between 2^h and 3^h, 3 when between 21^h and 22^h, 5 when between 22^h and 23^h, 0 when between 23^h and 0^h. There are no corresponding meridional observations. The whole number of separate observations of the moon and stars is 1058, and the whole number of observations of the collimator, 812.

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" A series of observations has been made for ascertaining any deviation from circularity in the form of the pivots of the vertical circle, but no sensible fault was found. * * *

" *Magnetical and Meteorological Observations.*—No change is made in the system of observations; photographic self-registration being applied to the principal magnetical and meteorological instruments, pencil self-registration being applied to the wind and rain, and eye-observations being intermingled for zeros. Commencing with 1856, August 25, the thermometers in the magnet-boxes have been read at twenty-four consecutive hours once in every week, with the view of obtaining bases for complete reduction of the observations. The regular observations of the maximum and minimum thermometers in the Thames have been interrupted, as has been stated above, but I hope that arrangements may be made for their restoration. * * *

" Mr. Main's examination of Bessel's Refraction Tables, to which allusion was made in the last Report, is completed; it shows that the correction required, though small, is distinct. The temperature coefficient can scarcely be improved.

" The account (by myself) of the construction of the national standards of length is completed.* Some supplementary works relating to the equipment of the Exchequer Office still require attention.

" The British Government had for some years past contributed by pecuniary grants to the preparation of Professor Hansen's Lunar Tables. In the last winter they undertook the entire expense of printing a large impression of the Tables. The reading of the proof-sheets (a very considerable labour) has been effected entirely at the Observatory. I may take this opportunity of stating that the use of these Tables has enabled me, as I think, incontestably to fix the capture of Larissa to the date B.C. 556, May 19. This identification promises to prove valuable, not merely for its chronological utility, but also for its accurate determination of an astronomical epoch, the point eclipsed being exactly known, and the shadow having been very small. Several calculations have been made in reference to this and the two other ancient eclipses (of Agathocles and Thales), which I am now preparing to combine in one system of calculation."

Formulæ of Navigation and Nautical Astronomy. Arranged by Capt. Charles F. A. Shadwell, R.N., C.B. London, 1856.

These formulæ are exhibited on a series of twelve cards, enclosed in a pocket-case. Each formula is accompanied by an explanatory statement which is in most cases illustrated by means of a simple diagram. The selection of formulæ includes all those which are required for the solution of the working problems of

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* A paper on this subject by the Astronomer Royal has been recently communicated to the Royal Society.—R. G.